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(71) Applicant; and
(72) Inventor: MALMSTRÖM, Anders, Edvard, Hugo [SE/-SE]; PL 404, S-380 31 Rockneby (SE).

(74) Agents: WIKLUND, Erik, et al.; Awapatent AB, Box 5117, S-200 71 Malmö (SE).

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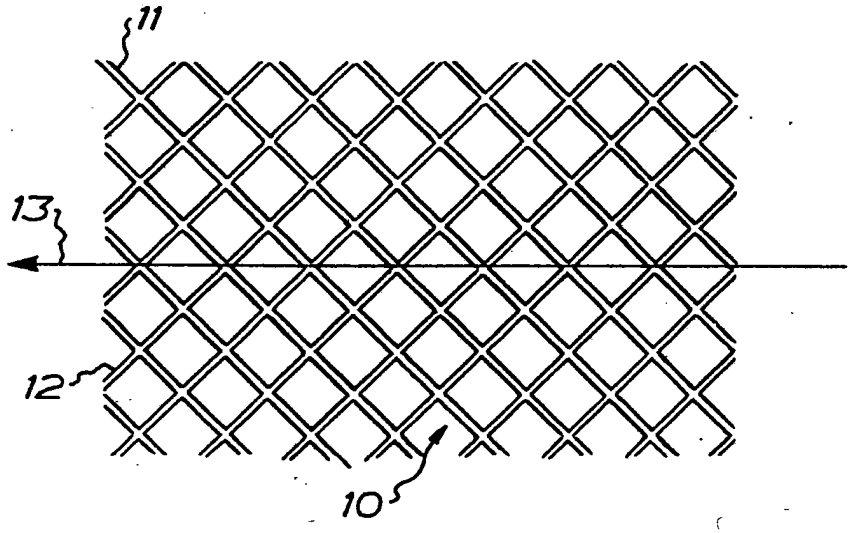

(57) Abstract

A surface structure of a surface (10) adapated for movement relative to a fluid, said surface structure consisting of intersecting band systems (11, 12). Each band system is in the form of ridges or depressions parallel to one another, and the two band systems (11, 12) form an angle with the relative direction of movement. This network of band systems (11, 12) prevents the formation of bursts, whereby the frictional resistance between the surface and the fluid is reduced considerably.

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SURFACE STRUCTURE OF A SURFACE ADAPTED FOR MOVEMENT RELATIVE TO A FLUID

The present invention relates to a surface structure of a surface adapted for movement relative to a fluid.

It is generally believed that a surface adapted for movement relative to a fluid is to be as smooth as possible. A well-known example of this is the conscientious manner in which the sailor grinds and polishes the outer surface of the hull. Another example is the transport of liquids in pipes where it is endeavoured to make the inside of the pipes as smooth as possible, in the belief that this will reduce friction losses. This belief is unwarranted; a given roughness reduces friction losses.

On various occasions, attempts have been made to roughen the surfaces of especially ship's hulls in order to reduce friction losses. Thus, British patent specification 357,637 of 27th June 1930 proposes to provide a hull with a coating having rasp-tooth formations. Here, one was on the right track, but no success was achieved because of the complicated formations and perhaps because of difficulty of coating a hull with plates of this type. Also on the right track is NASA Langley Research Center, Hampton, Virginia, according to a paper published by M.J. Walsh and L.M. Weinstein and entitled "Drag and Heat Transfer on Surfaces with Small Longitudinal Fins" (Seattle, Washington, July 10-12, 1978). According to this paper, fins of e.g. triangular cross-section are provided along a surface moving in a fluid. By "longitudinal" is meant that the fins are directed in the direction of movement of the surface. This arrangement offers a certain improvement as compared with a smooth surface, but the friction can be reduced to a far greater extent.

To illustrate the activity adjacent a surface adapted for movement relative to a fluid, reference is made to

a ship's motion in water.

The ship's motion is restrained by various factors, one of which is the frictional resistance, two forms of which are active, viz. laminar friction and friction produced by turbulence. The turbulent resistance is ultimately due to a flow transverse to the direction of movement and is many times greater per surface unit than the laminar resistance. It would be an ideal situation if the water flow along the surface could be kept laminar, and if the only deviation from the straight line were the water following the hull surface.

That part of the turbulent water layer which is adjacent the hull surface has previously been called the laminar sublayer, but recent research has shown that this layer exhibits an intense turbulent activity. The laminar friction and the slightest unevenness, also a microscopic unevenness, in the surface as well as different distances to this surface impart different velocities to the different water particles or particle groups. It should be noted that the different moving layers are not isolated from one another, and that a certain exchange of particle groups having different velocities is continuously taking place. In the contact, or friction, between particles of different velocity different degrees of "crowding" in different areas occur. In areas having a higher "crowding", a higher pressure arises, while in other areas the opposite occurs. This primary crowding effect forces the particles outwardly in different directions, which in turn causes further differences in the crowding intensity.

When a positive pressure is to be equalized in one area, the particle groups having the least kinetic energy (low velocity bands) and therefore requiring the least centripetal force for a change of direction, will change their direction, whereas the particle groups having a higher velocity will exert a smaller lateral pressure (Bernoulli's theorem), for which reason the particles

having the lower velocity and the higher pressure will tend to flow towards the area of smaller pressure. Since neither water nor air is compressed or rarefied at velocities below the velocity of sound, each such transverse flow will be compensated for by a return flow. The total effect of these phenomena results in flows forming an angle with the main direction of movement.

It has been established that the intensity of these flows shows a certain intermittence resulting in periodically recurrent bursts which constitute the main part of the total turbulence production.

The splashes which occur when a jet of water is directed against a surface are not the result of the rebounding of certain water particles; instead the particles are more or less powerfully forced out of the surface of the positive pressure produced by the crowding of the particles when they meet and are distributed along the surface. This positive pressure and consequently the splashes constitute, in principle, the same "crowding effect" as occurs during flow along a surface, the different degrees of the resulting pressure differences producing the bursts.

The present invention has for its object to eliminate these transverse flows and thus the formation of bursts by means of a surface structure such that the particles, when they "slide" along the surface, encounter other surfaces - not any type of unevenness - at an angle causing their velocity to be decelerated as far as possible, and that the particles, to the extent that they have not been stopped, but have changed their direction at reduced velocity, encounter other surfaces and one another, preferably from opposite directions. To this end, the surface has a structure comprising at least two intersecting band systems forming an angle with the direction of movement. In this manner, it is possible, when the optimum effect of this serial velocity deceleration is achieved, to dampen or cancel the intense turbulent activity adjacent the surface so that the innermost layer will be replaced

by a relatively calm layer where no bursts occur.

The surface structure according to the present invention may be in the form of bands of dams. Where appropriate, the dams may be replaced by channels in which the water then flows at a lower velocity and at a higher pressure (Bernoulli's theorem) than in the flow intersecting them.

The invention will be described in more detail in the following, reference been had to the accompanying drawing which diagramatically illustrates an embodiment of the invention.

The drawing shows a portion of a surface 10, for instance a surface on a ship or an aircraft with which the water och the air is in contact, or the inner surface of a pipe-line for conveying liquids or gases. The surface has two intersecting band systems of dams or ridges 11 and 12 which are parallel to one another and together constitute a network. The relative direction of movement between the surface 10 and the liquid or gas is indicated by the arrow 13. In the embodiment illustrated, the two band systems intersect one another at right angles, but other angles of intersection are also possible. In the example illustrated, the band systems form an angle of $+45^{\circ}$ and -45°, respectively, relative to the direction movement, but also these values are not critical. As has previously been mentioned, the band systems need not necessarily be in the form of dams, but may also consist of intersecting ditches or channels. The height of the ridges and the depth of the channels, respectively, may vary within certain limits, and it has been established that a height or a depth of less than 1 mm is fully adequate.

The drawing also shows continuous ridges, but the desired effect can be achieved also with discontinuous ridges, i.e. rows of mutually spaced apart elevations. The same applies, of course, also when the band systems are in the form of channels.

It will be appreciated that the production of the surface structure according to the invention is extremely

simple, which is an essential condition for its practical applicability. In actual practice, the ridges or channels may be formed by simple mechanical working of the surfaces that are swept by the water or the gas, but it is also possible to form the ridges or channels in compression moulded sheets which are glued or otherwise secured to the surfaces.

The present invention provides a simple and efficient surface structure in the form of a network effectively preventing the formation of bursts. In this manner, the frictional resistance of a relative movement of the type here concerned is reduced, and this means that the engine power of, for example, a ship can be reduced considerably without restricting the ship's speed. In other words, the invention offers a considerable saving of energy.

CLAIMS

1. A surface structure of a surface (10) adapted for movement relative to a fluid, c h a r a c t e r i s e d in that the structure has at least two intersecting band systems (11, 12) forming an angle with the direction of movement.

2. A surface structure as claimed in claim 1, c h a r a c t e r i s e d in that the two band systems (11, 12) intersect one another approximately at right angles.

3. A surface structure as claimed in claim 1, c h a r a c t e r i s e d in that the two band systems (11, 12) form an angle of approximately $+45^{\circ}$ and -45°, respectively, with the direction of movement (13).

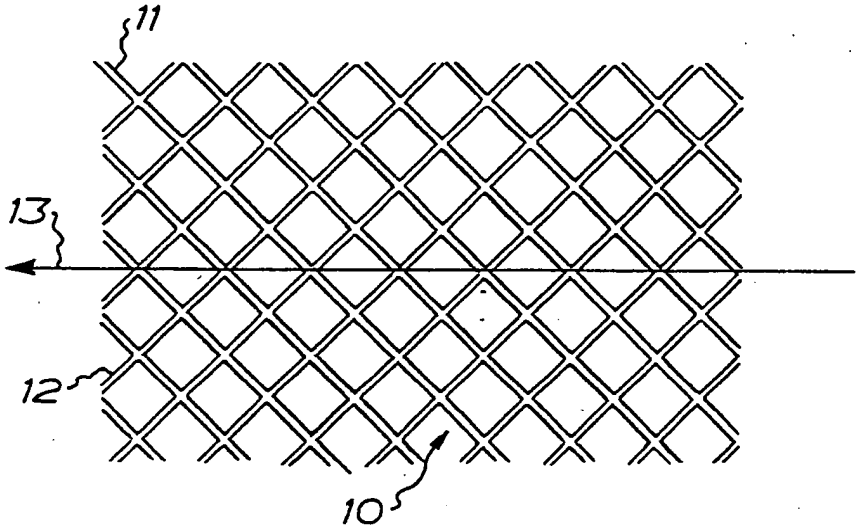
4. A surface structure as claimed in claim 1, 2 or 3, c h a r a c t e r i s e d in that the two band systems (11, 12) are formed by ridges parallel to one another.

5. A surface structure as claimed in claim 1, 2 or 3, c h a r a c t e r i s e d in that the two band systems are formed by channels parallel to one another.

6. A surface structure as claimed in claim 1, 2 or 3, c h a r a c t e r i s e d in that the two band systems (11, 12) are formed by spaced apart elongate elevations.

7. A surface structure as claimed i claim 1, 2 or 3, c h a r a c t e r i s e d in that the two band systems are formed by spaced apart elongate depressions.

8. A surface structure as claimed in any one of claims 4-7, c h a r a c t e r i s e d in that the ridges or elevations have a height and the channels or depressions have a depth, respectively, which is less than 1 mm.



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE80/00040

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC [3]

B 63 B 1/36, B 64 C 21/10

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 3	B 63 B 1/32-1/36; B 64 C 21/10
US Cl	114/66.5,67; 244/41,130,200
Deutsche Kl	65a :11,12

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	DE, A1, 2 508 103 published 1976, September 2, K Schmidt	
X	FR, A6, 38 951 published 1931, August 10, H Lecoq	
X	FR, A5, 937 494 published 1948, August 18, L P E Broçard	
X	GB, A, 14 627 published 1909, June 22, W H Fauber	
X	GB, A, 357 637 published 1930, June 27, P M Staunton	
X	GB, A, 1 034 370 published 1966, June 29, H Lackenby	
X	GB, A, 1 459 425 published 1976, December 22, Hydroconic Ltd	
X	US, A, 632 738 published 1899, September 12, J O'Hara	
X	US, A, 706 832 published 1902, August 12, I Lancaster	
X	US, A, 1 021 178 published 1912, March 26, F Riberstein	
X	US, A 1 454 479 published 1923, May 8, D R McCullough	
X	US, A, 1 480 408 published 1924, January 8, P K Miller	
X	US, A, 1994 045 published 1935, March 12, H W Nelson	

.../...

* Special categories of cited documents: [15]

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"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention

"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
1980-05-06	1980-05-19
International Searching Authority [1]	**Signature of Authorized Officer [20]**
Swedish Patent Office	K.-A. Löfroth

Form PCT/ISA/210 (second sheet) (October 1977)

International Application No. PCT/SE80/00040

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

III	Continuation Documents Considered to be Relevant	
X	US, A, 2 800 291 published 1957, July 23, A V Stephens	
X	US, A, 2 969 760 published 1961, January 31, G G Eddy	
X	US, A, 3 874 315 published 1975, April 1, E M Wright	

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers _____, because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers _____, because they relate to parts of the International application that do not comply with the prescribed requirements to such an extent that no meaningful International search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this International application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International search report covers all searchable claims of the International application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this International search report covers only those claims of the International application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.